

Application No.: 10/804,183
Amendment under 37 CFR 1.111
Reply to Office Action dated April 7, 2006
October 10, 2006

REMARKS

By this amendment, claim 6 has been cancelled and claims 1, 3, 4, 8 and 20 have been amended, in the application. Currently, claims 1-5 and 7-20 are pending in the application.

Examiner Akanbi and Examiner Rosenberger are thanked for the courtesies extended to the undersigned during the personal interview on September 7, 2006. During the interview, potential amendments to claims 1, 8 and 20 and the cited references including Zaroni (U.S. Patent No. 3,847,485) and the recently submitted JP references were discussed. Regarding independent claims 1 and 8, applicants' representative discussed amending the claims to recite that the objective lens scan portion was connected to the objective lens. Also, the objective lens scan portion has a rotational axis and the objective lens scan portion moves the objective lens in a second direction orthogonal to the first direction around the rotational axis was also discussed as defining over Zaroni and the references of record.

Also, regarding independent method claim 20, similar amendments were discussed. Specifically, the step of moving said objective lens by an objective lens scan portion in a direction orthogonal to the optical axis direction and around a rotational

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axis of the objective lens scan portion to move the measuring point on the measurement subject for which the displacement is calculated, was discussed. The Examiners also pointed out that claim 20 should be amended to include a step of outputting the result to satisfy the new guidelines. Accordingly, amending claim 20 to include a step of outputting the result of said step of calculating the two dimensional displacement by an operation processing portion, was discussed. By this amendment, these types of claim amendments have been made to independent claims 1, 8 and 20.

Regarding the office action, claims 1-3, 6-15 and 18-20 were rejected under 35 USC 102(b) as being anticipated by Zanon. Claims 5 and 17 were rejected under 35 USC 103(a) as being obvious over Zanon. Further, claims 4-5, 16-17 were rejected under 35 USC 103(a) as being obvious over Zanon in view of Kudo et al. (U.S. Patent No. 5,836,869).

These rejections are respectfully traversed in view of the amendments to claims 1, 8 and 20 and the remarks below.

The present invention relates to a displacement gauge and a method for measuring a displacement on the surface of a measurement subject such as metal, resin, glass, ceramic or paper by projecting a light onto the surface of the measurement

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subject, as well as a thickness meter for measuring the thickness of the measurement subject based on the same measurement principle.

As shown in Fig. 2, the displacement gauge comprises a light emitting portion for emitting light to be projected onto a measurement subject 16, an objective lens 15 for receiving light emitted from the light emitting portion and projecting light onto the measurement subject 16, an exciting portion for vibrating the objective lens 15 along a first direction at a preset amplitude, a position detector for detecting the position of the objective lens 15 that is moved in the first direction, a light diaphragm portion for passing a reflected light from the measurement subject 16, a light receiving portion for receiving light passing through the light diaphragm portion, and a displacement operation portion for acquiring a detected position from the position detector at the moment when the light received amount of light received by the light receiving portion is maximum, and calculating the displacement on the measurement subject 16 based on the detected position.

This displacement gauge further comprises an objective lens scan portion 52 for moving the objective lens 15 in a second direction orthogonal to the first direction, and an operation

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processing portion 58 for calculating the two dimensional displacement regarding the measurement subject 16, based on the measurement result of displacement at each measuring point, by moving the objective lens 15 along the second direction by the objective lens scan portion 52 to move a measuring point on the measurement subject 16 in a predetermined amount of movement and measuring the displacement at plural measuring points.

With this arrangement, the objective lens 15 is moved along the second direction orthogonal to the first direction, and the displacement amount at plural positions are measured consecutively while changing the measuring point. Hence, even if the displacement is unmeasurable at any one point, the displacement amount or its approximate value is obtained from the measurement results at its neighboring points.

The displacement gauge measures the displacement amount at a specified measuring point in the above way. Moreover, the displacement gauge can specify a plurality of measuring points. More specifically, a measuring area of the measurement object is specified by a measuring area specifying portion 51. The measuring area is specified by a line segment such as a circular arc or straight line. As a method for specifying the measuring area by the measuring area specifying portion 51, for example, a

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method for specifying the start point and end point of the line segment, or a method for directly specifying an adjustable curve may be appropriately employed. Also, a scan step as an interval between measuring points may be specified in the straight line or curve in the specified measuring area. Or the user may directly specify a plurality of measuring positions as the measuring points. Or the displacement gauge may automatically set up the measuring area based on the positions specified by the user. For example, the interval between measuring points may be set to a predetermined value with reference to the specified position.

The displacement gauge measures the displacement amount at each of the measuring points within the measuring area set up in the above way. The surface state of the measurement subject 16 is known based on the measured displacement amounts at the plural positions. For example, the profile, inclination, maximum height, minimum height, average height, height difference, and thickness for displaying the irregular shapes in the measuring area are calculated, and displayed, as needed. A display method involves displaying the profile of the measurement subject 16 as a sectional shape on the display of an output portion 66, as shown in Figs. 6 to 10. Also, the numerical values of average height, inclination and so on may be displayed together.

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With this method, since the displacement is measured at plural consecutive positions, it is possible to predict or compensate the displacement amount at any position, using the displacement amount measured at the neighboring measurable position, even when the measurement is not allowed at the position due to surface state of the measurement subject. Thereby, in employing the displacement gauge in which the spot size of light projected onto the measurement subject is small, the situation of measurement disabled is prevented.

Moreover, if the measuring area is changed from dot to linear form, the measurement is made with a spot size of light equivalently larger. For example, a predetermined line segment is specified as the measuring area, and the displacement amount is measured at each of plural measuring points within this measuring area, the average value of displacement amounts being calculated, whereby the displacement measurement is implemented equivalently with the spot size extended linearly.

In addition, since the profile within the measuring area can be measured, the height, height difference, step difference, width, and angle can be also measured in the two or three dimensional area. Particularly, the measurement results are statistically utilized by making the measurement at plural

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consecutive positions, whereby there is no trouble of specifying the measuring points individually, and the arithmetical operation for average, maximum value, minimum value and inclination is easily implemented, in which the environment is very easy to use. Further, the displacement amount at any single point may be measured by stopping the objective lens scan portion 52.

The movement of the measuring point is made by moving the objective lens 15. The objective lens 15 is moved in the direction orthogonal to the optical axis of light, and in the horizontal direction as shown in Fig. 4. Light incident on the objective lens 15 from the light emitting portion is made parallel light by the collimator lens 14. As a result, the focal distance in the optical axis direction is unchanged by moving the objective lens 15 in the direction orthogonal to the parallel light, whereby light is focused on the measurement subject 16 to allow the displacement measurement, as shown in Fig. 4.

The objective lens 15 is moved by the objective lens scan portion 52. The displacement gauge as shown in Fig. 2 comprises a servo motor 52A as the objective lens scan portion 52, and a rotational angle sensor 53A for sensing a rotational angle of the servo motor 52A, as an objective lens movement detecting portion 53 for detecting the position to which the objective lens 15 is

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moved by the objective lens scan portion 52. The exciting portion is rotatably connected to the servo motor 52A via a rotational axis 54 provided on a tuning fork holder 56 holding the tuning fork 21 that constitutes the exciting portion. The rotational axis 54 is positioned so that the objective lens 15 connected to the exciting portion may be moved along a plane orthogonal to the optical axis. In Fig. 2, the rotational axis 54 is penetrated through a trailing end portion of the tuning fork holder 56, whereby the tuning fork 21 is rotated within the horizontal plane, so that the objective lens 15 may receive parallel light from the collimator lens 14 perpendicularly. The rotation of the servo motor 52A is controlled by a scan position control portion 57 connected to the servo motor 52A. The scan position control portion 57 controls the rotation of the servo motor 52A, based on a scan position control signal output from an operation processing portion 58.

The rotational angle sensor 53A as the objective lens movement detecting portion is mounted to the rotational axis 54 of the servo motor 52A. The position of the objective lens 15 is detected by the rotational angle sensor 53A. The rotational angle sensor 53A sends an objective lens movement position signal to the scan position control portion 57, which controls the

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position of the objective lens 15 accurately based on an objective lens movement position signal and a scan position control signal. Also, the scan position control portion 57 reports the positional information of the objective lens 15 to the operation portion 20. Thereby, the displacement gauge scans while grasping the measuring position. The operation portion 50 receives the positional information of the objective lens 15, and the distance conversion portion 50 calculates the displacement amount at each measuring point and outputs the operation result to the operation processing portion 58. The operation processing portion 58 has a memory portion 59 holding the displacement amount at each measuring point. Predetermined operation processing is performed and the results are output, as needed. For example, the operation results may be displayed on the screen, printed by the printer, stored in a storage medium, or sent out to the external equipment for other processing.

The displacement gauge as shown in Fig. 2 has the measuring area specifying portion 51 for enabling the user to specify the desired measuring area. The measuring area is specified by specifying the area to be measured with the line. For the measuring area specifying portion 51, input means such as a console, a keyboard, a mouse or a touch panel may be adequately

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employed. The measuring area specifying portion 51 is equipped in the displacement gauge, or may be connected as a detachable member to a main body of the displacement gauge with or without the wire. Alternatively, an input device connected to the computer, to which the displacement gauge is connected, may be employed.

The measuring area specifying portion 51 is connected to the operation processing portion 58. When the user specifies the measuring area from the measuring area specifying portion 51, the operation processing portion 58 outputs a tuning fork position control signal and a scan position control signal to the tuning fork amplitude control portion 25 and the scan position control portion 57, respectively, based on the specified information to control them. Fig. 5 shows the outline of the scan position control signal. The measuring area is decided by the scan width that is a range for moving the objective lens 15, the scan center as the central position of movement, the scan period in moving the objective lens 15 periodically, and the scan step amount that is the movement amount at a time. When the user specifies the scan step and scan width, for example, the objective lens 15 is moved stepwise at the specified scan step. If the objective lens 15 is moved by the amount of scan width, it is turned back and

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moved in the opposite direction. The objective lens is periodically moved to scan over the surface of the measurement subject. The method is not limited to periodically scanning the objective lens 15, but may be implemented by specifying the path or point of measurement to move the objective lens 15 along the path specified by the user, or measure the displacement at any point.

The time or scan speed required for scanning is principally decided by the scan step and scan width. As the scan step is larger and the scan width is narrower, the scan speed is higher. On the other hand, as the scan step is smaller, the scan precision is higher, whereby the minute displacement measurement is allowed. Hence, the measurement area and its parameters are set to desired values in accordance with the balance between speed and precision.

On the other hand, in parallel to the scan position control signal, the tuning fork position signal is sent from the operation processing portion 58 to the tuning fork amplitude control portion 25, as shown in Fig. 5. Hence, the objective lens 15 is vibrated in the optical axis direction by the exciting portion, while being moved along the plane perpendicular to the optical axis, whereby the displacement is calculated by detecting

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the maximum value of the light receiving portion, as described above. Preferably, the objective lens 15 is vibrated in the optical axis direction over one period or more at each scan step by the exciting portion, thereby measuring the displacement at each step. To this end, the scan position control signal and the tuning fork position detecting signal are output synchronously by the operation processing portion 58.

By this amendment, independent claim 1 has been amended to recite "an objective lens scan portion ~~[[for]]~~ connected to said objective lens, said objective lens scan portion has a rotational axis, said objective lens scan portion moving said objective lens in a second direction orthogonal to said first direction around the rotational axis".

Also, independent claim 8 has been amended to recite "an objective lens scan portion ~~[[for]]~~ connected to said objective lens, said objective lens scan portion scanning said objective lens along a plane orthogonal to said optical axis direction in said measuring area specified by a measuring area specifying portion, said objective lens scan portion moving said objective lens relative to said light diaphragm portion". It is also noted that claim 8 also recites "a measuring area specifying portion

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for specifying a measuring area that is an object of measurement on said measurement subject".

Further, independent claim 20 has been amended to recite "a step of moving said objective lens by an objective lens scan portion in [[the]] a direction orthogonal to the optical axis direction and around a rotational axis of the objective lens scan portion to move the measuring point on said measurement subject for which the displacement is calculated" and also "a step of outputting the result of said step of calculating the two dimensional displacement by an operation processing portion".

Applicant respectfully submits that none of the prior art of record shows a displacement gauge of claims 1 and 8 or a method of claim 20 as currently amended.

Zanoni discloses a surface sensor such as shown in Fig. 7. As shown, Zanoni does not disclose an objective lens scan portion connected to the objective lens or the objective lens scan portion having a rotational axis or the objective lens scan portion moving the objective lens in a second direction orthogonal to the first direction around the rotational axis, as claimed in claim 1.

Also, Zanoni does not disclose an objective lens scan portion connected to the objective lens or the objective lens

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scan portion moving the objective lens relative to the light diaphragm portion, as claimed in claim 8. Further, Zanoni does not disclose a measuring area specifying portion for specifying a measuring area that is an object of measurement on the measurement subject as claimed in claim 8.

Further, Zanoni does not disclose or suggest "a step of moving said objective lens by an objective lens scan portion in a direction orthogonal to the optical axis direction and around a rotational axis of the objective lens scan portion to move the measuring point on said measurement subject for which the displacement is calculated" as recited in claim 20.

Kudo et al. does not make up for the deficiencies in Zanoni. Kudo et al. discloses an image tracking endoscope system without the features discussed above related to claims 1, 8 and 20.

Also, the recently submitted Japanese references such as JP Patent Publication No. 8-320208 do not include the features added to claims 1, 8 and 20.

Therefore, Zanoni, Kudo et al, and the other references of record, do not teach or suggest, individually or in combination, the presently claimed invention.

In view of foregoing claim amendments and remarks, it is respectfully submitted that the application is now in condition

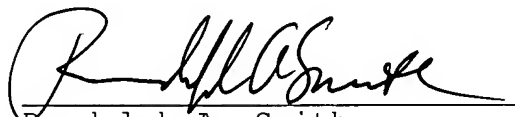
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for allowance and an action to this effect is respectfully
requested.

If there are any questions or concerns regarding the
amendments or these remarks, the Examiner is requested to
telephone the undersigned at the telephone number listed below.

Respectfully submitted,

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